Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

THE EFFECT OF MALARIA AND HOOKWORM UPON PHYSICAL AND MENTAL DEVELOPMENT OF SCHOOL CHILDREN

TRUMAN L. KELLEY
University of Texas

Last spring a health campaign was conducted jointly by the Texas State Health Department, the University of Texas Extension Department, and the International Health Board in three rural districts in east Texas. The object was to show, in an unquestionable manner, the enormous magnitude and the nature of the loss resulting from malaria, typhoid, hookworm, and dysentery, to establish the feasibility of suppressing these diseases at small cost, and to impress upon the people of the state the values resulting from such elimination. In connection with this campaign Dr. A. Caswell Ellis, who was in general charge of the work as pertaining to the University of Texas, asked me to attempt to determine the physical and mental effects of malaria and hookworm upon the school children in the communities concerned. My problem was specifically to try to discover, if existent, and to measure some of the more subtle losses consequent upon these diseased conditions. By means of a house-to-house canvass and individual questioning other workers in this campaign ascertained such tangible facts as "the number of days lost due to sickness," "the amount of doctors' bills," "the number of deaths," etc., but they could not have even proposed the question, "What is your lessened mental acumen due to your attacks of malaria?" It is a question in the minds of doctors and laymen whether malaria has a continuing mental effect. Although the dulling mental and physical effects of hookworm have been proclaimed by the medical profession, this view is not accepted by the countryman whose children and neighbors' children are suffering from the ravages of this disease.

In the endeavor to secure some definite information upon these points, four physical and four mental tests were given to all the school children in attendance in three schools, in April, 1916, when the health campaign started, and again in November, six months later. After the final examination and grading, the children were classified into groups upon the basis of their hookworm and malaria history. A comparison of the improvements in the various groups during the six months makes possible an evaluation of the effect of the diseases.

Forty-seven children were free from malaria and hookworms at the time of the first examination, and remained so during the summer. The pupil's statement as to malaria and the doctor's as to hookworms are the means of ascertaining these facts. These forty-seven constitute the "control group." Nine children who were free from malaria, but had hookworms at the time of the first examination, remained free from malaria and were cured of hookworms. These will be called "the cured-of-hookworm group." Eleven constitute a "cured-of-malaria group." Eleven constitute a "cured-of-hookworm, cured-of-malaria group." This is not an exhaustive classification, but the other groups, such as "free from hookworm, contracted malaria," possess small populations of two, three, or four. These small groups yield irregular results, though generally confirmatory of those given by the larger groups. The three groups of nine, eleven, and eleven—those cured of malaria, or hookworm, or both since the time of the first examination—have been united and will be referred to as "a cured-of-disease group." The numbers of individuals in these groups are not large, but as the measures of importance in this study are those showing the differences in standing between the first and second examinations, and as these are differences between highly correlated measures, the probable errors of the results are much less than might at first be supposed.

Inaccuracies of one sort or another are often involved in noting the improvement in gross scores, and, on the basis of this, concluding that one group improves more than the other. These difficulties have been excellently discussed by Strong.[1] Without attempting here an adequate discussion of the question, I would point out that these difficulties are in large part obviated by measuring improvement on a scale, the units of which are equally spaced in terms of a normal distribution. Strong, himself, illustrates this fact in a discussion of Ayres's handwriting scale. Accordingly, the method followed was to test by means of material that could be divided into two parts, each of which permitted a grading upon the same scale basis, and then to measure the difference in improvement in the various groups by noting their differences in gross scale scores.

---

[1] Edward K. Strong, Jr., *Effects of Hookworm Disease on the Mental and Physical Development of Children.* International Health Commission. Publication No. 3. The Rockefeller Foundation, New York, 1916.

The Starch arithmetic, Thorndike reading, and Trabue completion tests excellently meet these conditions. The Courtis arithmetic test was given because it also can be so divided that a second test, though involving new material, can be graded upon the same basis as the first. The results of the Courtis test were worked up just as the others, but it should be borne in mind that the scores with this test are not scores on a scale, and such disturbing factors as the difference in psychological significance of improvement at different ages corresponding to equal improvement in gross score are not allowed for.

These tests are all school tests, but with the exception of the Courtis, success in which depends mainly upon drill, they are essentially tests of reasoning. Given sufficient reading ability to understand the words used, success in them is very much more dependent upon intellectual alertness than upon school training. It should be further noted that three-fourths of the time between the two tests came during the school vacation. This point is mentioned to show that it is reasonable to attribute different results in the various groups to the difference in conditions of health, and not to other factors. A reference to Table I shows that the difference in age between the "control" and other groups cannot be responsible for the differences found. The "control group" and the "cured-of-disease group" differ in age by but 0.02 year.

Four physical measurements were obtained, viz., weight, vital capacity, grip (average of both hands), and speed of tapping for thirty seconds (average of both hands). The scores for these are not scaled measures. For example, a given number of pounds increase in weight at the age of six is not equal in terms of its significance to the same number of pounds increase at the age of twenty. However, none of the children, with the possible exception of two or three girls, had completely passed puberty, so that the gross measures of increase do not have decidedly different meanings at the different ages examined, and, as noted, the average ages of the different groups lie near together.

These eight tests tell somewhat different stories as to the effect of the diseases studied. The group increases and related data are given in Table I.

The "control group" shows an average increase in weight during the six months of 4.4 pounds. The "cured-of-malaria group" increased 5 pounds, or 114 per cent of the increase of the "control group." The "cured-of-hookworm group" increased 4.7 pounds, 107 per cent, and the "cured-of-malaria and cured-of-hookworm group" increased 5.5 pounds, 125 per cent. Combining these three groups, we find that the "cured-of-disease group" increased on the average 5.1 pounds, 116 per cent of that of the "control group." The difference between the average increase in weight of the two groups is 0.7 pound, and its probable error is 0.6 pound, showing that the chances are about four to one that the excess increase in weight of the cured group is significant. A perusal of the original data shows that the omission of a single exceptional case from the "control group," a girl who increased twenty pounds in the six months, would raise the excess increase to 1.1 pounds and lower the probable error to about 0.5 pound. These data, therefore, rather strongly indicate that the suppressed vitality due to hookworm and malaria tends to come back with renewed vigor when the suppressing disease is cured.

A small group of three was found who constitute a "contracted-malaria group." This group suffered an average loss in weight, for the six months, of 2.7 pounds. The group is too small to yield conclusive evidence, but it strongly indicates that the onset of malaria seriously impedes growth, and we have found that cure from it and hookworm leads to a spurt in growth. The gain, however, is not as pronounced as the setback. It would seem that, though there is recovery, it does not entirely compensate for the loss. The age at the time of onset of the disease and its duration

TABLE I

Average Increases of Various Groups and Probable Errors of Same

Groups	Numbers of Individuals in Groups	Average Ages of Groups	Weight P.E.	Vital Cap. P.E.	Grip Average of Two Hands P.E.	Tapping Average of Two Hands P.E.	Courtis Sum of "Rights" P.E.	Starch Arithmetic Scale P.E.	Thorndike Reading Scale Alpha 2. P.E.	Adaptation of Trabue Completion Scale P.E.
Control......	47	12.3	4.4..0.4	11.8..1.4	−0.8..0.26	6.1.. 2.7	−0.2..0.5	0.7..0.2	−0.15..0.13	0.32..0.13
Cured-of-hookworm..	9	11.1	4.7..0.9	14.1..3.2	−0.4..0.60	13.0.. 6.2	−2.4..1.1	1.8..0.5	0.34..0.28	−0.02..0.29
Cured-of-malaria....	11	14.7	5.0..0.8	15.3..2.8	−0.6..0.54	5.3.. 5.6	−1.2..1.0	1.1..0.5	−0.19..0.26	0.59..0.26
Cured-of-both	11	10.9	5.5..0.8	14.9..2.8	0.4..0.52	8.5.. 5.6	−0.4..1.1	0.9..0.5	−0.41..0.27	1.00..0.26
Cured-of-disease.....	31	12.3	5.1..0.5	14.8..1.7	−0.2..0.32	....	−1.3..0.6	1.2..0.3	− .11..0.16	0.54..0.16
Contracted-malaria....	3	16.3	−2.7..1.5	− 2.7..5.5	−3.5..1.00	7.5..10.7	0.0..1.9	1.7..0.9	0.70..0.49	0.60..0.50
Differences										
Cured-of-disease minus control........	....	0.0	0.7..0.6	3.0..2.2	0.6..0.41	....	−1.1..0.8	0.5..0.4	0.03..0.20	0.22..0.21
Contracted-malaria minus control........	....	4.0	−7.1..1.6	−14.5..5.6	−2.7..1.03	....	0.2..2.0	1.0..0.9	0.84..0.51	0.28..0.52
Correlations between First and Second Tests—Control Group										
			0.9925	0.958	0.972	0.866	0.899*	0.903*	0.895	0.900

* These two coefficients are larger than would have been found if scores of individuals making zero on both tests had not been included in the calculation.

probably both affect the amount of recovery. A child who is seriously diseased during the years of rapid growth, if completely cured before an adult age is reached, will probably show a decided spurt, but it is equally likely that he will never attain the development he would have reached had he not been ill. The data suggest that much the same consequences follow upon disease of long duration as upon malnutrition, which consequences are stated in these words of Child:[1]

> The results of return to a normal diet after a period of insufficient nutrition apparently depend in part upon the length of that period. It has been clearly demonstrated that in man as well as in animals the retarding effect upon growth of even a considerable period of insufficient nutrition may be compensated later on a normal diet. But it is also true that a sufficiently long period of underfeeding may result in permanent "stunting," the body apparently being unable to recover its full capacity for growth. . . . . After a long period of underfeeding the tissues are physiologically older, and therefore less capable of growth, even when nutrition is present in excess, than in the continuously well-fed animal of the same size.

The data for vital capacity show exactly the same tendencies, but more conclusively. The increase of the "control group" was 11.8 cubic inches, and the increase of the "cured-of-disease group," 14.8 cubic inches, 125 per cent, an excess increase of 3 cubic inches, while the "contracted-malaria group" actually shows a loss of 2.7 cubic inches.

In strength of grip the "cured-of-disease group" shows an increase of 0.6 kg. over the "control group," with a probable error of 0.4 kg. The group cured of both diseases shows an increase in excess of that of the normal group of 1.2 kg., with a probable error less than half as great.

There is no warrant for combining the hookworm and malaria groups with reference to tapping, for it is found that those cured of hookworm increase more rapidly and those cured of malaria less rapidly than normal. The "cured-of-hookworm group" increases 3.1 taps in thirty seconds more than the "control group," but the "cured-of-malaria group" increases 2.5 taps less than the normal group. This may be because they have been relieved of a certain nervous tension, but the probable errors of these particular results make any conclusion that may be drawn merely tentative.

---

[1] C. M. Child, *Senescence and Rejuvenescence* (1915), pp. 281–82.

Speed of tapping is the only one of these measures which shows a gain with the contraction of malaria, all the others showing an improvement with cure. In the case of hookworm all the measures show an improvement with cure.

The mental tests do not yield as conclusive data, not so much because the differences in improvement are less pronounced, as because the correlations between the first and second tests are smaller, thereby making the probable errors of these differences larger. The "cured-of-malaria," the "cured-of-hookworm," and the "cured-of-both" groups all show less improvement with the Courtis tests in fundamentals than is shown by the "control group." In none of these cases, however, is the difference more than half as large as its probable error, so this result may be due to chance, or, as already suggested, to the crudity of the measure used. The score in the Courtis test was the sum of the "rights" in the time allowed for the four fundamental operations. The score is not a scaled measure; it is one of speed (note in this connection the speed of tapping results) and has a large probable error, any or all of which facts may be responsible for the result found.

The Starch arithmetic test shows uniformly greater improvement with the cured groups than with the "control group."

The improvement of the "control group" in the Thorndike reading test is very much less than that of the "cured-of-hookworm group," about the same as that of the "cured-of-malaria group," and 0.3 of a unit more than that of the "cured-of-both group." Combining, it is found that the "cured-of-disease group" shows up slightly better than the "control group."

With the Trabue completion test the "control group" increases less than the "cured-of-malaria group," decidedly less than the "cured-of-both group," but improves slightly more than the "cured-of-hookworm group." Combining the groups, we have these figures: increase in the Trabue completion test by the "diseased-but-cured group," 0.54 Trabue unit; increase by the "control group," 0.32, difference, 0.22, with a probable error of 0.21.

Thus the Starch, Thorndike, and Trabue tests, on the whole, show that there is a spurt attendant upon cure. Taking the three tests together, the chances are very much in favor of the spurt being a genuine one, but the data are not sufficient to establish its magnitude. It does, however, seem to be apparent that there is not as great a spurt as in the case of the physical traits.

These data, so far as the physical measures are concerned, are in entire harmony with the findings of Dr. C. W. Stiles, as reported by Strong, but so far as the mental development is concerned they differ radically from Strong's findings. The difference might possibly be attributed to the difference in method, but since Strong's first and second examinations were but three and one-half months apart, it is very likely that sufficient time had not elapsed to permit the benefits of cure being fully realized. It is, of course, also possible that the time between the tests in this study, six months, is not sufficient completely to cover the period of gain after cure. Strong reports that children cured of hookworm progress mentally more rapidly than would have been the case if they had not been cured, but less rapidly than normal, whereas the conclusion from the data just presented would be that in mental as well as in physical traits they improve after cure more rapidly than normal. In this connection I quote a paragraph from a lecture delivered by Dr. A. Caswell Ellis, showing the money cost of malaria, hookworm, typhoid, and dysentery:

> Finally, we have the most nearly accurate account yet secured of the actual kinds and amounts of preventable diseases present in our lowland, coastal plain country. In the approximately two hundred white families studied, there were four deaths from malaria last year, and an average of 2.4 attacks per person. There was a money loss from preventable disease of $77.00 per family, on account of doctors' bills, medicine, nursing, and loss of time from work. There was a per capita loss of $15.71 for the whites. The negroes had just as much sickness, but because of neglect the cost was about half that of the whites. The total immediate cost of preventable disease, as far as this could be recalled at the end of the year by 179 white and 119 negro families studied, was $17,703.00. Of this, malaria caused the loss of $12,258.00. As there are about a million people living along the coastal plain of Texas, equally exposed to these attacks, it means that last year one-fourth of the population of Texas alone paid a preventable disease tax of about fifteen million dollars, including a malaria tax of about ten million. In addition, they suffered the pain of more than two million attacks of malaria, and lost over four thousand loved ones by death. East Texas is no worse nor better than the rest of the Gulf and Atlantic coastal plain, at least as far up as Virginia, and the valleys of the Mississippi, Missouri, Ohio, and a thousand and one other rivers and creeks in the temperate and semi-tropical parts of America. Multi-

ply the millions of cases of suffering and the millions of money loss that are now proven in Texas by the number of millions inhabiting the anopheles infested coastal plain and river and creek bottoms, and you will have some idea of the hundreds of millions of money and the frightful tribute of human pain and misery that we stupidly pay each year, when our experience seems to show that for less than one-seventh of the actual amount lost each year we can immediately and permanently prevent more than half of this loss, and in a few years practically all of it.

The national government spends hundreds of thousands per year on hog culture and hog cholera, hundreds more on cattle culture and cattle ticks, and yet the fund allowed Dr. von Ezdorf this year for malaria work is just nineteen thousand dollars for this vast empire. When I pleaded with Congress for a small sum to start this work in Texas, I was solemnly assured by a distinguished member that it might prove a very bad precedent; that if the work succeeded, the whole country would want such help, and that it would cost a billion dollars before the country was freed from these diseases. The fact that that billion would save fifty thousand lives and a billion dollars per year made no dent in the crust of his mind.

To this cost I would add another, the lessened physical and mental excellence due to malaria and hookworm. When we consider that in mental make-up there is but little difference between the leader of finance of \$10,000.00 or \$20,000.00 a year and his secretary at \$2,000.00 a year—that just a little extra makes a man boss of a gang instead of one of its members—the seriousness of weakened physical and mental life and its money value assume proportions which make the cost of cure a pittance too small to weigh against the benefits derived from it.

To recapitulate the points brought out by this study: (1) Cure from hookworm leads to an immediate increase in physical and mental development beyond the normal rate. (2) Cure from malaria leads to immediate increase in physical and mental development beyond the normal rate, except in the case of tapping. (3) Contraction of malaria leads to a decided checking, except in the case of tapping. This is supported by data from three individuals. (4) The spurt attendant upon cure is not as great as the retardation attendant upon contraction. (5) The money cost of cure is entirely incommensurate with its benefits. (6) It is hoped that studies similar to Strong's and the one here reported will awaken people generally to the blessings at hand at such small expense and will encourage them to endeavor to secure these blessings.